College Physics 201
Circular Motion

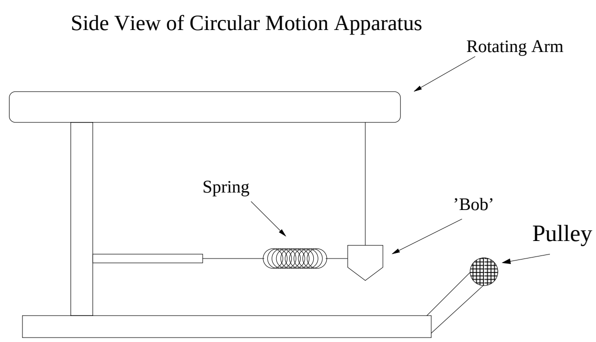
Materials: *Circular motion apparatus, stopwatches, laptop computers, short rulers, heavy mass sets with 50-g hangers*

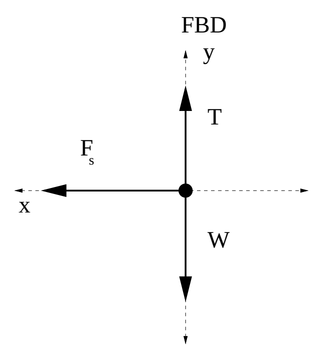
1 Purpose

The purpose behind this lab is for the student experimenters to investigate the centripetal motion and the force which keeps an object in circular motion. Students will continue to refine their analysis skills.

2 Introduction

The uniform circular motion of an object can be studied using the following apparatus.





From the FBD for this system, we see that the circular motion of the 'Bob' is caused by the force supplied by the spring, F_s. This force is constant throughout the experiment. The net force in the x-direction is thus the spring force. This then is equal to the centripetal force so we can represent this as

$$F_s = m\frac{v^2}{R}. \tag{1}$$

With this apparatus, the experimenter measures the rotational period of the pendulum 'Bob' as a function of total 'Bob' mass, m, so it is necessary to replace the v with an equivalence in terms of T. Replacing the v with

$$v = \frac{2\pi R}{T} \tag{2}$$

and solving for T yields

$$T = \left(\frac{4\pi^2 R}{F_s}\right)^{1/2} m^{1/2}. \tag{3}$$

We can now measure the dependence of the the rotational period on the mass of 'Bob'. Note here that the theory in Eq. 3 predicts the relationship to be a power law form so for complete analysis you will have to perform a logarithmic analysis.

3 Procedure

Follow all the instructions of your lab instructor. They will point out important aspects of the apparatus. Make sure you tighten down all set screws and attachments after making changes.

3.1 Rotational Period Measurements

1. Carefully detach the pendulum 'Bob' and measure it's mass. Reattach it to the apparatus **WITHOUT** attaching the spring.
2. Measure the radius of rotation for the pendulum 'Bob' when it is in its fully vertical position. (Note: Do not rotate the system!) Make the radius **18.0 cm**
3. Reattach the spring to the pendulum 'Bob'.
4. Rotate the system until the 'Bob' is perfectly vertical while being rotated. This requires a bit of practice.
5. Once you are comfortable, measure the period of rotation for **10** complete rotations of the 'Bob' and record the **period** in a table of the 'Bob's' total mass versus rotation period. NOTE: Think about what the period is and its relationship to the time you measured. They are not equal!
6. Repeat the measurement two more times and average the results. This will help to minimize stopwatch starting and stopping uncertainties.
7. Add 40-grams to the 'Bob' and repeat steps 4 through 5. Do this for 100-g, 140-g, 200-g, 240-g, and 300-g added to the 'Bob'. The last couple of mass additions will require additional "modifications".

3.2 Spring Force Measurement

Measure the amount of force in the spring when the 'Bob' is vertical by attaching a string to the opposite side of the 'Bob' and suspending mass over the small pulley on the apparatus.

1. Attach a string to the 'Bob' so it can be strung over the small pulley.
2. Place a 50-g hanger on the end of the string and add mass until the 'Bob' is vertical while not rotating.
3. Record the amount of mass suspended on the end of the string. This is the mass necessary to 'balance' the spring force. Thus, we know have a direct measurement of the spring force since for this system in equilibrium since $T = mg$.

4 Analysis

1. Generate a table that has the following columns: total mass of pendulum 'Bob' (including added mass), each period measurement, average of all three measurements, square root of bob's mass, natural log of the period, and natural log of the total mass of the pendulum 'Bob'. Are you in SI units?
2. Generate a plot of *Natural log of period vs. natural log of total 'Bob' mass* and fit the result with a straight line.
3. Generate a plot of *Period vs. square root of total 'Bob' mass* and fit the result with a straight line.